

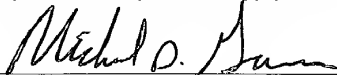
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PATENT

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR UNITED STATES LETTERS PATENT

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SEED PLANTER APPARATUS AND METHOD

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RELATED APPLICATIONS

10 This application is a continuation-in-part and claims priority to U.S. Application No. 08/581,444, filed December 29, 1995 and U.S. Application Nos. 08/702294, 08/700214, 08/700225, 08/700217, and 08/700222, filed August 20, 1996, the entire disclosures of the foregoing applications are incorporated herein by reference. The following U.S. Applications entitled: "Seed Tube For Seed Metering Apparatus"; "Seed Planter Self-Tensional Transmission"; "Automatic Coaxial Engagement Drive Coupler;" "Seed
15 Metering System With Improved Wear Enhancement"; and "Hopper System", all of which were filed on April 15, 1998, and the entire disclosure of each of these applications are incorporated herein by reference.

FIELD OF THE INVENTION

20 The present invention generally relates to seed planters including seed metering mechanisms for dispensing individual seeds at a controlled rate into a seed furrow as the seed meter is advanced above and along the furrow and, more particularly, to a vacuum seed metering mechanism in which a rotating disc element coupled to a vacuum source picks up individual
25 seeds from a seed mass and subsequently discharges the seeds therefrom in a controlled fashion as the seed disc continuously rotates.

BACKGROUND OF THE INVENTION

30 Seed planters generally include meters of various designs have been used for sometime to dispense seeds at a controlled rate into a seed furrow as the seed meter is advanced above and along the seed furrow. In a typical arrangement, a tractor is coupled to tow a tool bar to which are attached in a generally parallel, spaced apart relation a plurality of planting units with seed

meter arrangement attached thereto. Each planting unit typically includes a seed hopper for containing and carrying a large quantity of seeds to be planted or a smaller container fed from a centralized in or large hopper, a device for opening a furrow in the ground as the tractor drawn tool bar is advanced across the field over the ground, a seed meter is coupled to the seed hopper for dispensing individual seeds into the furrow at a controlled rate, and a further device for moving soil at the sides of the furrow to close the furrow over the seeds.

During a planting operation, the tractor typically moves across the field at speeds of about 4 to about 8 miles per hour. The spacing between adjacent individual seeds in each furrow can be as little as 0.5 inches or less or as much as 10 inches or more depending upon the particular seed being planted. The seed metering mechanism therefor must be capable of dispensing seeds at various rates in the order of to 130 seeds per second or greater as well as at rates which are considerably less. The many different types of seeds to be planted using a seed metering mechanism include corn, cotton, sorghum, sugar beets, soybeans and sunflowers to name a few. As will be appreciated, such seeds vary considerably in size, weight and shape. For example, peanut and edible bean seeds are among the largest seeds for planting and have elongated irregular shapes and outer surfaces. Soybean, and pelletized seeds are smaller and tend to be rounder and vary in shape and size. Sorghum and raw sugar beet seeds have a rounder almost spherical appearance. Sorghum seeds have a relatively smooth outer surface. On the other hand, raw sugar beet seeds have a very rough and irregular outer surface configuration. Cotton seed is small and shaped like some corn seed. On the other hand, corn seeds have a somewhat triangular shape with generally flat sides.

Despite these numerous differences in the size, shape and surfaces of such seeds, seed meters are expected and are required to handle all different types of seeds described above plus many more while requiring minimum effort regarding part changes and adjustments. At the same time, required spacing and depth standards of planting accuracy typically mandate a low error rate. A missed seed or doubling of seeds is undesirable and may be

tolerated only very infrequently. Such requirements place considerable demands upon the accuracy of the seed metering mechanisms.

Some seed metering mechanisms used in planting operations of the type discussed above are of the mechanical type and include a vertical or horizontal seed plate or disc with mechanically actuated fingers or similarly operated mechanical devices for separating individual seeds from the seed disc and then dispense them into the furrow. While some mechanical seed meters are satisfactory for certain applications, they typically suffer from a number of limitations including the limited speed at which they can accurately dispense seeds, and inability to handle different type seeds without making cumbersome and extensive part changes, and an inherent design complexity which may typically add to the cost, wear and maintenance problems of the mechanically operated seed dispensing mechanisms.

Alternatively, a seed metering mechanism which utilizes an air pressure differential has been developed in an effort to overcome some of the problems of the mechanical seed meters. Air pressure differential seed meters, which are commonly known as air seed meters, are generally of two types. The first type being the positive pressure type and the second type relying upon negative pressure or vacuum.

In the positive pressure type of air seed metering mechanism, air is blown into the seed chamber and onto the surface of a rotating or otherwise movable and apertured member or disc in order to create the higher than atmospheric pressure in the chamber. This forces seeds from a seed mass onto the seed member or disc where they are retained for later release. The apertures or holes in the rotating member or disc open to atmosphere where the individual seeds are held by the blowing air until the seeds are dispensed by interrupting the flow of air to the seeds.

While air seed meters of the positive pressure type offer certain advantages over mechanical seed meters, they have certain limitations of their own which may prove to be a significant disadvantage for various seeding applications. In an effort to fill each hole or opening with a seed as the seed disc rotates through the seed mass, a relatively high pressure differential is applied to the disc. Because the seeds are held in place on the

rotating disc or other movable member by differential pressure resulting from positive pressure in the chamber, it is usually necessary that the air flow be directed through the seed mass to aid in the depositing of individual seeds onto the disc. The air flow has been found to interfere with the orderly
5 delivery of seeds from the disc and, ultimately, to the ground. In positive pressure seed metering mechanisms, the seed hopper must be sealed to maintain pressure in the system. If for any reason the hopper lid comes off or the hopper otherwise becomes unsealed, the seed meter will not properly function.

10 Vacuum seed meters have been found to overcome some of the problems in the positive pressure seed meters and offer more control over the seed being transported by the seed disc. In vacuum seed meters, a vacuum source is typically coupled to a separate chamber on the opposite of the seed disc from the seed mass with the vacuum communicating through the
15 apertures in the seed disc to the seed mass. The vacuum is of sufficient magnitude such that it tends to draw seeds into the openings defined by the disc and hold the seeds thereto as the seeds are moved through the seed disc under the influence of the moving seed disc toward the seed discharge area of the seed metering mechanism. The openings between the outer
20 surface of the seeds and the periphery of the openings in the disc allows air to pass therethrough thereby maintaining the seeds in operable association with the disc. Because the pressure differential at the seed disc comes from a vacuum source on the opposite side thereof and not from the flow of air at the same side thereof as with positive pressure type seed metering
25 mechanisms, the problem of having to direct an air flow through the seed mass and on to the seed disc are eliminated.

Despite the various advantages of vacuum seed meters over seed meters of the positive pressure type, presently known vacuum seed meters are not without problems of their own. For one thing, testing has revealed
30 that when vacuum seed metering mechanisms are used some seeds tend to be drawn rotationally under the influence of the moving seed disc and the vacuum in the discharge area of the seed metering mechanism rather than gravitationally falling for deposit to the ground. Testing has also revealed

that the air drawn through the openings between the outer surface of the seeds and the periphery of the openings in the seed disc in the seed discharge area of the seed metering mechanism tends to flow upwardly into the seed metering mechanism in a direction opposed to the direction the seeds are intended to flow under the influence of gravity. Moreover, some vacuum seed metering mechanisms include a seed disc having a pocket or recess arranged in radially extending relation relative to the opening for accommodating a seed therewithin. When the respective openings reach the seed discharge area whereat the vacuum to the seed disc is cutoff, the seeds carried in the pockets tend to move with the disc. The seeds entrapped within the pockets and moving rotationally with the disc, however, tend to interfere with other seeds being released from the disc in the seed discharge area thereby effecting accurate seed spacing between adjacent individual seeds.

Accordingly, it would be desirable to provide a seed planter which includes vacuum seed metering mechanism wherein the release of seeds from the disc is effected positively without seeds sticking or hanging onto the seed disc or releasing erratically therefrom as a result of the vacuum used in combination with the seed mechanism. Moreover, providing a seed disc with a low friction seed release advantageously eliminates or significantly reduces the tendency or likelihood of the seeds to be, carried with or rotationally move with the seed disc allows the seeds discharged from the seed metering disc to be readily and reliably released from the seed disc without the need for complicated release mechanisms.

SUMMARY OF THE INVENTION

One aspect of the invention provides a seed planter apparatus comprising a seed meter including a housing assembly including a cover releasably connected to a shell and including at least one opening formed in the housing assembly adjacent a seed discharge area to promote the release of seeds from a disc rotatably attached to the housing assembly. The disc divides an interior of the housing assembly to include a vacuum chamber and a seed chamber. The disc includes a plurality of openings formed adjacent a

periphery of the disc.

A further aspect of the invention provides a method of operating a seed planter apparatus. A housing assembly including a cover releasably connected to a shell is provided. The housing assembly includes at least one opening formed in the housing assembly adjacent a seed discharge area. A disc is rotatably attached to the housing assembly and divides an interior of the housing assembly to include a vacuum chamber and a seed chamber. The disc includes a plurality of openings formed adjacent a periphery of the disc. The disc is rotated. The seeds are held at the disc openings while the disc openings are in communication with the vacuum chamber. The seeds are released from the openings as the disc openings exit from the communication with the vacuum chamber. Air is flowed through the opening formed in the housing assembly to promote the release of seeds from the disc.

A further aspect of the invention provides a seed planter apparatus comprising a seed meter including a vacuum chamber, a seed chamber, and a seed disc. The seed disc includes a plurality of spaced apart clusters formed therein. Each of the clusters includes a plurality of communicating openings to allow seeds held by differential pressure within the openings of each cluster to release the seeds together as the cluster exists from communication with the vacuum chamber.

A further aspect of the invention provides for a method of operating a seed planter apparatus. A seed meter including a vacuum chamber, a seed chamber, and a seed disc, is provided. The seed disc includes a plurality of spaced apart clusters formed therein with each of the clusters including a plurality of communicating openings. The seed disc is rotated in communication with a vacuum chamber. The seeds are held within the cluster openings. The cluster is rotated out of communication with the vacuum chamber. The seeds are released from the openings of each cluster substantially simultaneously.

A further aspect of the invention provides a seed planter apparatus comprising a seed meter including a housing assembly, including a chute portion and a seed chamber. The chute portion including a first opening for

receiving seed from a hopper which communicates with the first opening. The chute includes a second opening formed therein. A bar extends from a portion of the chute and positioned above the second opening. A door is shaped to cover the second opening and includes a clip portion for

5 snap-fitting onto the bar to allow the door to rotate on the bar.

A further aspect of the invention provides for a method of operating a seed planter apparatus. A seed meter including a housing assembly with a chute portion and a seed chamber is provided. The chute portion includes a first opening in communication with a hopper and a second opening formed

10 therein. A bar extending from a portion of the chute and positioned above the second opening with a door shaped to cover the second opening with a clip portion snap-fitted to the bar is also provided. The door is rotated about the bar. The seed is passed from the hopper through the first opening. And, the seed is passed through the second opening.

15 A further aspect of the invention provides for a seed metering apparatus for a seed planter comprising a housing including a seed chamber opening for communicating with a hopper, and a baffle rotatably attached to the housing. The baffle including a body portion and a handle portion. The handle portion extending through an opening formed in the housing. And the

20 housing including a plurality of notches formed on an outer surface of the housing to allow the handle to be positioned within the notches to rotate the body portion and vary the size of the seed chamber opening.

A further aspect of the invention provides for a method of operating a seed metering apparatus for a seed planter. A housing including a seed

25 chamber opening for communicating with a hopper, a baffle rotatably attached to the housing with a body portion and a handle portion is provided. The handle extends through an opening formed in the housing. The housing includes a plurality of notches formed on an outer surface of the housing. The handle is moved between the notches. The handle portion is retained in

30 the notch. The body portion is rotated to vary the size of the seed chamber opening.

A further aspect of the invention provides for a seed metering apparatus for a seed planter comprising a housing assembly including a

singulator assembly attached thereto and including at least one spool rotatably attached to a body portion of the singulator assembly. The spool includes a circular cross-section and the spool is in contact with a seed disc. The seed disc includes a plurality of openings formed adjacent a periphery of the disc. The spool partially covers the openings.

A further aspect of the invention provides for a method of operating a seed metering apparatus for a seed planter. A housing assembly including a singulator assembly attached thereto is provided. The singulator assembly includes a plurality of spools rotatably attached to a body portion of the singulator assembly. A seed disc including a plurality of openings formed adjacent a periphery of the disc is also provided. A seed disc contacts with the spools. The openings of the seed disc are partially covered with the spools. The spools are contacted by the seeds and the spools are rotated.

The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention rather than limiting, the scope of the invention being defined by the appended claims and equivalents thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic right side elevational view of a planting unit with a seed metering mechanism in accordance with the present invention mounted thereon;

FIG. 2 is a rear perspective view looking forwardly of a seed hopper with a seed metering mechanism according to the present invention mounted thereon;

FIG. 3 is an enlarged right side elevational view of the seed metering mechanism with a fragmentary portion of a seed tube shown connected thereto;

FIG. 4 is a front elevational view of the seed metering mechanism of the present invention disassembled from the seed hopper;

FIG. 5 is a left side perspective view of the seed metering mechanism

accor the present invention;

FIG. 6 is a sectional view taken along line 6-6 of **FIG. 4**;

FIG. 7 is an enlarged fragmentary view of the portion encircled by line 7-7 in **FIG. 6**;

5 **FIG. 8** is an enlarged fragmentary view of the portion encircled by line 8-8 in **FIG. 6**;

FIG. 9 is an exploded perspective view of the seed metering mechanism of the present invention;

10 **FIG. 10** is a right perspective view of a housing component forming part of the seed metering mechanism of the present invention;

FIG. 11 is an enlarged right side view of the housing component illustrated in **FIG. 10**;

FIG. 12 is a sectional view taken along line 12-12 of **FIG. 3**;

FIG. 13 is a sectional view taken along line 13-13 of **FIG. 3**;

15 **FIG. 14** is a left side view of the housing component illustrated in **FIG. 1**;

FIG. 15 is an enlarged left side view of a portion of the housing illustrated in **FIG. 14**;

20 **FIG. 16** is an enlarged left side view of the portion of the housing encircled in **FIG. 15**;

FIG. 17 is a right side view of a baffle used in combination with the housing present invention;

FIG. 18 is an end view of the baffle illustrated in **FIG. 17**;

25 **FIG. 19** is a perspective view of a driven hub forming part of the seed metering mechanism of the present invention;

FIG. 20 is a perspective view of a drive hub forming part of a drive assembly of the seed metering mechanism of the present invention;

FIG. 21 is a right side view of the drive hub illustrated in **FIG. 20**;

30 **FIG. 22** is a rear elevational view of the drive hub illustrated in **FIGS. 20 and 21**;

FIG. 23 is a perspective view of an agitator assembly used in combination with the seed metering mechanism of the present invention;

FIG. 24 is a right side view of the agitator assembly shown in **FIG. 22**;
FIG. 24a is a sectional view taken along line 24a-24a of **FIG. 24**;

FIG. 25 is an enlarged elevational view of a central portion of the agitator assembly showing a series of springs forming an integral part of the agitator assembly;

5 **FIG. 26** is a sectional view taken along line 26-26 of **FIG. 24**;

FIG. 27 is a right side view of one form of a seed metering plate to be used in combination with the seed metering mechanism of the present invention;

FIG. 28 is an end view of the seed metering plate shown in **FIG. 26**;

10 **FIG. 29** is a right side view of a singulator apparatus arranged in combination with the seed metering mechanism of the present invention;

FIG. 30 is an exploded perspective view of the singulator apparatus shown in **FIG. 29**;

15 **FIG. 31** is a right side view of a base forming part of the seed singulator;

FIG. 32 is a sectional view taken along line 32-32 of **FIG. 31**;

FIG. 33 is a sectional view taken along line 33-33 of **FIG. 31**;

FIG. 34 is a perspective view of one form of singulator mount forming part singulator assembly;

20 **FIG. 35** is a right side view of the singulator mount shown in **FIG. 33**;

FIG. 36 is a top elevational view, partly in section, of the singulator mount illustrated in **FIG. 35**;

FIG. 37 is a perspective view of another singulator mount forming part of the singulator apparatus shown in **FIGS. 29** and **30**;

25 **FIG. 38** is a right side view of the singulator mount shown in **FIG. 37**;

FIG. 39 is a top plan view of the singulator mount shown in **FIG. 38**;

FIG. 40 is a perspective view of an actuator for the singulator apparatus;

FIG. 41 is a right side view of the actuator shown in **FIG. 40**;

30 **FIG. 42** is an end view of the actuator shown in **FIG. 40**;

FIG. 43 is a side view of a cover forming part of the singulator apparatus of the present invention;

FIG. 44 is a sectional view taken along line 44-44 of the cover illustrated in **FIG. 43**;

FIG. 45 is an elevational view of a spool stud forming part of the singulator apparatus shown in **FIGS. 29** and **30**;

5 **FIG. 46** is an end view of the spool stud shown in **FIG. 45**;

FIG. 47 is an elevational view of one form of singulator spool that can be used in combination with the singulator apparatus of the present invention;

FIG. 48 is a side view of the singulator spool illustrated in **FIG. 47**;

FIG. 49 is a partial sectional view taken along line 49-49 of **FIG. 48**;

10 **FIG. 50** is a partial sectional view taken along line 50-50 of **FIG. 48**;

FIG. 51 is an exploded perspective view of an alternative embodiment of a seed metering mechanism, seed hopper, and removable lid;

FIG. 52 is a perspective view of the embodiment of **FIG. 51** assembled;

FIG. 53 is an enlarged view of a portion of the embodiment of **FIG. 52**;

15 **FIG. 54** is a perspective view of an alternative embodiment of a housing;

FIG. 55a is a perspective view of an alternative embodiment of a seed metering mechanism attached to a seed hopper;

FIG. 55b is a front view of the embodiment of **FIG. 55a**;

20 **FIG. 55c** is a cross-sectional view taken along line A-A of **FIG. 55b**;

FIG. 55d is a side view of the embodiment of **FIG. 55b**;

FIG. 56a is a front view of an alternative embodiment of a cover;

FIG. 56b is a back view of the embodiment of **FIG. 56a**;

25 **FIG. 57** is a perspective view of an alternative embodiment of a seed baffle;

FIG. 58 is an exploded perspective view of an alternative embodiment of a seed metering mechanism;

FIG. 59 is a reversed exploded perspective view of the embodiment shown in **FIG. 58**;

30 **FIG. 60a** is a seed side view of an alternative embodiment of a seed disc;

FIG. 60b is a vacuum side view of the embodiment of **FIG. 60a**;

FIG. 60c is a seed side view of an alternative embodiment of a seed disc;

FIG. 60d is a vacuum side view of the embodiment of **FIG. 60c**;

FIG. 61a is a seed side view of an alternative embodiment of a seed disc;

FIG. 61b is a vacuum side view of the embodiment of **FIG. 61a**;

FIG. 62a is an enlarged view of a cluster of openings of the embodiment shown in **FIG. 61a**;

FIG. 62b is an enlarged view of a cluster of openings of the embodiment shown in **FIG. 61b**;

FIG. 63a is a front view of an alternative embodiment of a housing;

FIG. 63b is a back view of the embodiment of **FIG. 63a**;

FIG. 64 is an exploded perspective view of a seed metering apparatus which includes an alternative embodiment of the singulator assembly of the present invention;

FIG. 65 is a front perspective view of the singulator assembly illustrated in **FIG. 64**;

FIG. 66 is an exploded perspective view of the singulator assembly illustrated in **FIG. 65**;

FIG. 67 is a front perspective view of an alternative embodiment of a base of the singulator assembly;

FIG. 68 is a back perspective view of the base illustrated in **FIG. 67**;

FIG. 69 is a perspective view of one embodiment of the housing;

FIG. 70 is a perspective view of an alternative embodiment of a bracket of the singulator assembly of the present invention;

FIG. 71 is a perspective view of an alternative embodiment of a second bracket of the singulator assembly of the present invention;

FIG. 72 is a perspective view of an alternative embodiment of the cover of the singulator assembly of the present invention;

FIG. 73 is a perspective view of an alternative embodiment of a mounting stud of the singulator assembly of the present invention;

FIG. 74 is a perspective view of an alternative embodiment of

singulator spool of the singulator assembly of the present invention;

FIG. 75 is a side view of the singulator spool illustrated in **FIG. 74**;

FIG. 76 is a plan view of the singulator spool illustrated in **FIG. 74**;

FIG. 77 is a front view of an alternative embodiment of an agitator

5 made in accordance with the invention;

FIG. 78 is a back view of the embodiment of **FIG. 78**;

FIG. 79 is a perspective view of an alternative embodiment of a drive rotor made in accordance with the invention showing the seed disc engaging side;

10 **FIG. 80** is a back view of the embodiment of **FIG. 79**;

FIG. 81 is a plan view of the seed disc engaging side of the drive rotor of **FIG. 79**; and

FIG. 82 is a back view of the embodiment of **FIG. 81**.

15 **DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS**

While the present invention is susceptible of embodiment in different forms, there is shown in the drawings and will hereinafter be described a preferred embodiment of the invention with the understanding that the
20 present disclosure is to be considered as setting forth an exemplification of the present invention which is not intended to limit the invention to the specific embodiment illustrated.

Referring now to the drawings, wherein like reference numerals indicate like parts throughout the several views, a seed planting apparatus or
25 implement is schematically illustrated in **FIG. 1** and is represented in its entirety by reference numeral **10**. Seed planting apparatus or implement **10** includes an elongated tool bar **12** which is supported for movement across and over fields by a plurality of wheels (not shown) and which is adapted to be towed in a given forward direction by a power source such as an
30 off-highway tractor or the like. Attached to the tool bar **12** are a plurality of planting units **14**; with only one being illustrated and described in detail and from which a complete understanding of the present invention may be readily determined. As is well known in the art, the planting units **14** are mounted in

side-by-side relation relative to each other along the length of the tool bar **12**.

In the illustrated embodiment, each planting unit **14** preferably includes a conventional furrow opening apparatus generally indicated in **FIG. 1** by reference numeral **18**. As is known in the art, the furrow opening unit **18** preferably includes a pair of lateral spaced furrow opener discs **21**, a furrow forming point, and an opener shoe **24**. Alternatively, and without detracting or departing from the spirit and scope of the present invention, the planting unit **14** can be provided with a runner opener type for providing a furrow in the ground. The planting unit **14** further includes a pair of furrow closer discs **26** and a press wheel **28** arranged in fore-and-at relationship relative to each other.

A seed hopper **30** is likewise carried on each planting unit **14**. The purpose of the seed hopper **30** is to provide storage for seed material that is to be gravitationally deposited to the ground as the planting unit moves over and across the field. It will be appreciated that a hopper container, smaller than that exemplified in the drawings, and connected to a centralized bin or large hopper would equally suffice without detracting or departing from the spirit and scope of the present invention. In the illustrated embodiment, a seed metering mechanism or apparatus **32** is arranged in seed receiving relation relative to the hopper **30** and, in the illustrated embodiment, forms part of the planting unit **14**. The purpose of the seed metering apparatus or mechanism **32** is to uniformly release seeds received from the seed hopper **30** for deposit onto the ground. To facilitate delivery of seeds from the seed metering mechanism **32** to the ground, a vertically disposed seed tube **34** is mounted on the planting unit **14**. The seed tube **34** is preferably of the type disclosed in co-pending and co-assigned patent application Serial No. 08/581,444, filed December 29, 1995, in the illustrated embodiment, the full disclosure of which is incorporated herein by reference. Suffice it to say, the seed tube **34** defines a vertical passage **36** through which seeds are delivered to the ground.

FIGS. 51-53 illustrate an alternative embodiment of a seed hopper **801** and a seed metering mechanism **802**. A removable lid **804** may include an

opening **806** for receiving a flexible tether **808**. The flexible tether **808** may be secured to both the lid **804** and the seed hopper **801** so that when the lid **804** is removed, the lid **804** remains tethered to the seed hopper **801**. This assures that the lid **804** remains in close proximity to the seed hopper **801** and prevents the lid **804** from being blown away when operating in windy conditions. As shown in **FIG. 51**, the lid **804** may include at least one hook **810** integrally formed on an inside surface **812** of the lid **804**. In the embodiment shown, three hooks **810** are provided which are oriented in three different directions. When the lid **804** is removed from the seed hopper **801** during operation, the lid **804** may be conveniently hung on the seed hopper **801** by positioning the lid **804** so that at least one of the hooks **810** engage an edge **814** of a sidewall of the seed hopper **801**. Since the hooks **810** are oriented in different directions, the lid **804** can be mounted to the seed hopper **801** either vertically or horizontally in various positions along the edge **814** of the sidewalls of the seed hopper **801**. Moreover, the position of the three hooks **810** provides an ergonomically convenient configuration for both left and right handed operators.

As the power source or tractor pulls the tool bar **12** across and over the ground, the furrow opening apparatus **18** operates to open a furrow in the ground. Seeds from the hopper **30** flow into the seed metering mechanism **32** from whence seeds are introduced at a controlled rate into the seed tube **34** to uniformly move through the vertical passage **36** defined by tube **34** and are, ultimately, deposited onto the ground. The furrow closer **26** trails the furrow opening apparatus **18** and, as the seed planter apparatus **10** is drawn across the field, serves to close the furrow together and over the seed dispensed by the seed metering mechanism **32** into the furrow. The trailing press wheel **28** serves to compact the soil closed over the seeds.

In the illustrated embodiment, a pesticide hopper **38** is mounted toward a rear end of each planting unit **14**. Hopper **38** preferably includes an insecticide and is provided with conventional dispensing means for applying controlled amounts of insecticide where desired in connection with the planting of seeds by each planting unit **14**.

According to the present invention, the vacuum seed metering mechanism or apparatus **32** is mounted to and movable with the hopper **30** relative to frame structure **33** (**FIG. 1**) of the seed planting unit **14** and relative to the seed tube **34**. Moreover, the hopper **30** is mounted on and removable from the planting unit **14** in a conventional manner. As shown in **FIG. 2**, the seed metering mechanism **32** includes a split housing assembly **40** arranged toward the bottom of and in seed receiving relation relative to the seed hopper **30**. The seed metering apparatus **32** mounted to each planting unit **14** (**FIG. 1**) is individually connected via a suitable flexible conduit **42** to a common vacuum source (not shown) suitably mounted for movement over and across the field.

As shown in **FIGS. 2** through **5**, the housing assembly **40** of the seed metering mechanism **32** has a generally cylindrical-like configuration measuring about 300 mm. in diameter. The housing assembly **40** is comprised of a housing or shell **44** that is rigidly secured to the seed hopper **30** and a cover or shell **46** releasably connected to shell **44**. In the preferred form of the invention, the cover **46** is completely removable from the housing **44** when access to the interior of the seed metering mechanism **32** is desired or required. Preferably, a series of manually releasable fasteners **48** are equidistantly arranged about the periphery of the housing assembly **40** for releasably fastening the housing **44** and cover **46** in operable and substantially air tight relation relative to each other. In the illustrated embodiment, three fasteners **48** are provided for releasably securing the cover **46** to the housing **44**.

The cover **46** of the split housing assembly **40** is preferably formed as a unitary or one piece member that is formed with sealing surfaces and suitable cutoffs as an integral part thereof. As such, the seed metering mechanism of the present invention does not require additional parts to be added thereto to effect sealing such as rubber seals and the like. In the illustrated embodiment, the cover **46** is formed of a rigid nylon or thermoplastic material containing conventional antistat and/or other low friction agents such that no graphite, talc, or slick additives need to be used

in combination with the seed metering mechanism of the present invention during operation thereof. Graphite powder, however, may be used. Moreover, and as shown in **FIG. 6**, cover **46** of the split housing assembly **40** has an arcuate shaped chamber **50** extending about 270 degrees and adjacent the periphery of the cover **46**. As will be described in detail hereinafter, an exhaust or suction port **52** opens to the chamber **50** intermediate opposite ends thereof. As is conventional, the flexible conduit **42** is exteriorly connected to the exhaust port **52** such that a vacuum or negative pressure may be created in the chamber **50** when the cover **46** is fastened to the housing **44**.

Chamber **50** in housing **46** is partially defined by a first annular or circular flat sealing face **54** formed integral with an inner surface **56** of the cover **46**. Also arranged on the inner surface **56** of cover **46**, in radially spaced congruent relation from the sealing face **54**, is a second sealing face **58** that is likewise formed integral with the inner surface **56** of cover **46**. Notably, the sealing faces **54** and **58** are arranged in generally planar relation relative to each other and are formed integral with the cover **46** thus eliminating the need or requirement for additional separate rubber seals. Moreover, and as shown in **FIG. 6**, outwardly spaced from the sealing face **58**, cover **46** defines a flat circular lip area **60** extending radially outwardly to the periphery of the cover **46**. Notably, both the first and second seating faces **54** and **58** axially project from the inner surface **56** of the cover **44** beyond the circular lip area **60**. Cover **46** furthermore defines a leg portion **62** that is generally coplanar with the flat lip area **60** and which extends tangentially away from one end of chamber **50**.

FIGS. 56a-b illustrates an alternative embodiment of a cover **840** which includes at least one discharge opening **842** formed therein adjacent to and extending radially inward from the perimeter of the cover **840**. In the embodiment shown, three discharge openings **842** having a generally rectangular shape are provided. The discharge openings **842** allow waste material such as peanut husks, for example, which may be pulled through the seed disc openings and trapped between the seed disc and the cover, to be

19

discharged from the seed metering mechanism during operation. The number, size, shape, and positioning of discharge openings **842** may vary depending on the particular application. A slot **843** may preferably be formed in the cover **840** adjacent the exit area of the vacuum chamber. Air which

5 flows through the slot **843** creates a cut-off curtain of air to enhance the cut-off response of the vacuum thereby improving the timing and release of the seed drop. The size and shape of the slot **843** may vary depending upon the particular application. A perimeter cover opening **844** may be formed in the cover **840** to provide a passageway to view an edge of a seed disc and to

10 discharge debris along the edge of the perimeter of the disc. The cover **840** may preferably have a vacuum gauge opening **841** formed therein which penetrates into the vacuum chamber to allow an operator to determine the pressure within the vacuum chamber. As shown in **FIG. 56a**, a mechanical ramp **845** is provided adjacent one of the discharge openings **842** to divert

15 debris collected on the vacuum side of the disc away from the seed metering mechanism. As shown in **FIG. 56b**, a plurality of triangular-shaped depressions **846** are formed along the seed disc contact surface **847** of the cover **840**. The depressions **846** divert abrasive debris away from the seed disc contact surface **847**. The size, shape, and orientation of the depressions

20 **846** may vary depending upon the particular application. The cover **840** may be comprised of a plastic resin including, for example, Estaloc™ grade 61083 manufactured by BF Goodrich Company. Estaloc™ has been found to have very low shrink characteristics to allow the cover **840** to be molded with a flat contact surface which is important for holding an acceptable vacuum contact

25 surface. In forming the cover **840**, use of Estaloc™ also has been found to provide a consistent surface variation pattern on the vacuum contact surface. Estaloc™ also has been found to have excellent wear characteristics in an abrasive environment. Additives may be added to the Estaloc™ to make the cover **840** resistant to static charge build-up or to make it electrically

30 conductive, to enhance seed spacing performance and to dissipate static electricity to prevent shock.

As shown in **FIG. 7**, the inner and outer radially spaced sealing faces

54 and 58, respectively, are joined, at one end, by a first radial web 64 that separates a leading end of vacuum chamber 50 from a seed discharge area of the seed metering mechanism 32 as will be discussed in detail below. In the illustrated form of the invention, the radial web 64 is preferably formed integrally with the cover 46 and has a flat sealing face 66 that is generally coplanar with the sealing faces 54 and 58 of cover 46.

As shown in FIG. 8, the opposite or trailing end of chamber 50 is defined by a second radial web 68 defining a vacuum cut-off for the chamber 50. The radial web 68 is preferably formed integral with the cover 46 and likewise has a flat sealing face 70 formed planar with the sealing faces 54 and 58 of cover 46. Notably, cover 46 further defines an inclined ramp 72 radially extending through the chamber 50 and toward the vacuum cutoff 58.

Turning now to FIG. 9, component assemblies of a preferred form of the seed metering mechanism 32 of the present invention are schematically illustrated in exploded perspective relative to each other. As shown, the seed metering mechanism 32 of the present invention preferably comprises the housing 44, a manually operated baffle assembly 100 that is operably adjusted from outside the housing assembly 40 of the seed metering mechanism 32, a drive assembly 200, an agitator assembly 300 for inhibiting seeds from compacting within the housing assembly 32, a seed disc or plate 400 that operably divides the interior of the housing assembly 32 into a seed chamber 74 (FIG. 4) between one side of the seed plate 400 and the interior of housing 44 and the vacuum chamber 50 between the opposite side of the seed plate or disc 400 and the cover 46, a singulator assembly 500 for inhibiting more than one seed from being advanced by the seed plate or disc 400 to the discharge area of the seed metering mechanism 32, a vibration mechanism 800 for facilitating the release of seeds from the disc 400 in the discharge area of the seed metering mechanism 32, and the cover 46 for closing the seed metering mechanism 32.

As shown in FIGS. 10 and 11, housing 44 of the seed metering mechanism 32 is preferably formed from a metal material and includes a generally planar back wall 76 having inner and outer surfaces 78 and 80,

respectively. An annular hub **82** is formed at the center of the housing **44** and axially projects inwardly from the inner surface **78**. The annular hub **82** defines a central bore **83** defining a longitudinal axis **84** for the seed metering mechanism **32**.

5 As shown in **FIGS. 12 and 13**, the drive assembly **200** axially extends through and is rotatably mounted within the hub **82** of housing **44**. As shown in **FIGS. 9 through 11**, housing **44** defines a circumferential skirt or rim **85** that axially projects forwardly from the inner surface **78** in surrounding relation to a substantial portion of outer periphery of housing **44**.

10 As shown in **FIGS. 12 and 13**, an annular portion of the edge of rim **85** cooperates and combines with the flat lip area **60** on the inner surface **56** of cover **46** to close the housing assembly **32**. Notably, the area surrounded by rim **85** and between the seed plate or disc **400** and the inner surface **78** of the housing **44** defines a seed reservoir or chamber **86** wherein seeds are stored.

15 As shown in **FIGS. 10 and 11**, the annular rim or skirt **85** has arcuate areas **88** and **90** that are recessed from the remainder of the edge. When the cover **46** is fastened to the housing **44**, these recessed areas **88, 90** define circumferentially extending openings **89 (FIG. 4)** and **91 (FIG. 13)** allowing atmospheric air to enter the housing assembly **32** and maintain the seeds releasably attached to the disc **400** as a function of the differential air pressures between the suction chamber **50** and the opposite side of the housing **32**.

20 As shown in **FIGS. 5, 10 and 14**, the outer surface **80** of housing **44** defines a lug **92** which facilitates connection of the housing assembly **32** to the hopper **30**. As shown, housing **44** further defines a chute **94** that allows and directs the gravitational flow of seed between the hopper **30 (FIG. 5)** and the seed reservoir or chamber **86 (FIG. 12)**. In this regard, the back wall **76** of housing **44** defines an opening **96 (FIGS. 10 and 11)** that allows seeds to pass from the chute **94** into the seed reservoir area or chamber **86** of the seed housing assembly **32**.

25 The chute **94** may also include an opening to allow an operator to remove seeds from the hopper **30**. For example, as shown in the alternative

embodiment of **FIGS. 54-55**, the housing **820** includes an opening **822** formed in a chute **824** to allow seeds to be drained from the seed hopper **801**. As shown in **FIGS. 55a-d**, a door **826** is rotatably attached to the chute **824**. In particular, a clip portion **829** of the door **826** snaps onto a bar **828** which is formed in the chute **824**. The snap-fit clip portion **829** provides simple and convenient means to attach the door **826** to the chute **824**. The direction of the snap-in clip portion **829** opposes the direction of force that the seeds exert so that the clip portion **829** cannot snap off the bar **828** while in use. As shown in **FIG. 55a** and **FIG. 55c**, the door **826** may be locked into a closed position by pin **830**. In the embodiment shown, the pin **830** slides through a collar **827** formed in the door **826** to provide a positive door lock. The pin **830** may include a ring portion **830a** which engages a ring retaining tab **825** formed on the housing **820** to lock the pin **830** in place. The door **826** may be locked into the closed position by any suitable means including, for example, mechanical fasteners, latches, etc. As shown in **FIG. 55d**, when the door **826** is unlocked and opened to drain seeds from the seed hopper **801**, the door **826** automatically positions itself vertically so as to not disrupt the seed flow. The door **826** may be comprised of any suitable rigid material including, for example, steel or plastic. In the embodiment shown in **FIG. 55a**, the door **826** includes a plurality of strengthening ribs **821** formed on an outer surface **821a** of the door **826** to provide increased rigidity to ensure that the door **826** remains flat to cover the entire opening **822**. The number and configuration of the ribs **821** may vary depending on the amount of rigidity desired.

Referring to **FIGS. 10** and **11**, housing **44** further defines a wall **97** spaced radially inwardly from rim **85** and axially projecting from the inner surface **76** of housing **44**. The space or open area **95** between the rim **85** and wall **97** defines a seed exhaust area **98** for the seed metering mechanism **32**. The exhaust area **98** opens at its lower end to the seed tube **34** (**FIG. 1**) and through which the seeds released from the seed plate **400** gravitationally move, ultimately, for deposit onto the ground. In this regard, the back wall **76** of housing **44** defines a series of vertically spaced openings **99** that allow atmospheric air to pass into the exhaust area **98** and facilitate the flow of

seeds toward the seed tube **34** by eliminating or significantly reducing the air drawn upwardly into the seed discharge area **98** of the seed metering mechanism. In the preferred embodiment of the invention, and as shown in **FIGS. 15** and **16**, the openings **99** preferably have slotted or elongated configurations. Alternatively, the openings **99** may be any other shape or configuration to allow air to pass into the exhaust area **98**. For example, in the embodiment shown in **FIG. 55**, the openings **823** may preferably have a circular configuration.

Returning to **FIG. 3**, when the cover **46** is releasably attached to the housing **44**, a substantial portion of chamber **50** extends through the seed reservoir area **86** of housing **44**. Moreover, the leading end of the vacuum chamber **50** is disposed proximate to but remains outside of the discharge chute **98** of the housing **44**. At its other end, suction chamber **50** terminates toward the upper end of the discharge area or chute **98** such that seeds released from the seed plate **400** pass downwardly into the discharge chute **98** and pass gravitationally toward the seed tube **34**. Moreover, with the cover **46** so arranged on the housing **44**, leg portion **62** of the housing overlies and closes the open side of the discharge chute **98** defined by housing **44** to prevent seeds released from the seed disc from inadvertently escaping from the housing assembly **32**.

In the embodiment shown in **FIG. 59**, a wear strip **860** is secured to an inner surface **862** of a wall **864** of the housing **820** to prevent any wear that may be caused by the rotation of an agitator **866**. The wear strip **860** may preferably be comprised of a rigid material including, for example, plastic. The plastic may preferably be comprised of, for example, ultra high molecular weight polyethylene.

In the embodiment shown in **FIG. 59**, an annulus brush **870** may preferably be mounted within the housing **820** to prevent seeds from exiting the seed chamber through a gap formed between the housing **820** and a perimeter edge of a seek disc **872**. The annulus brush **870** may be comprised of any rigid material including, for example, plastic. A linear brush **874** may also preferably be mounted within the housing **820** to prevent seeds

from exiting the seed chamber. The linear brush **874** may include a brush portion **875** which cleans debris away from openings **876** formed in the seed disc **872** as the disc rotates in operation. As shown in **FIGS. 58** and **59**, a screen **880** may be positioned between the housing **820** and the cover **840** to prevent seeds which are circulated within the seed reservoir chamber by the agitator **866** from exiting the seed reservoir chamber. Moreover, the screen **880** preferably has a suitable amount of openings to allow air to pass into the interior of the seed metering mechanism, while at the same time preventing airborne debris from entering the interior of the seed metering mechanism. The screen **880** may preferably be comprised of a rigid material such as, for example, plastic. Also shown in **FIG. 59**, a removable screen or guard **861** may be positioned within the housing **820** to prevent seeds in the seed chamber which are contacted by the agitator **866** from entering the seed discharge area of the housing **820**.

The purpose of the seed baffle assembly **100** is to control the seed level in the seed reservoir **86** from outside of the housing assembly **40**. With the present invention, and as mentioned above, the cover **46** is preferably removable from the housing **44**. After the cover **46** is removed and the seed plate **400** is removed, the seeds in the reservoir **86** will tend to pour out to the ground. Moreover, if there is nothing to close the opening **96** at the bottom of the chute **94**, the seeds in the supply hopper **30** will likewise tend to pour onto the ground. Accordingly, the present invention provides the seed baffle assembly **100** for selectively allowing the operator to choose the level of seed mass in the reservoir **86** from outside of the housing **44**. That is, and unlike other seed metering mechanisms, the seed baffle assembly **100** is adjustable from the outside and does not require the operator to gain access to the interior of the seed metering mechanism **32** in order to close off the opening **96** leading from the hopper **30**.

As shown in **FIGS. 9, 17** and **18**, the seed baffle assembly **100** comprises a seed baffle **102** having a general planar configuration. The seed baffle **102** defines a generally central throughbore **103** that allows the seed baffle **102** to be mounted for rotation about the hub **82** of the housing **44** of

housing assembly **40**. As shown in **FIG. 12**, the seed baffle **102** is configured to mount in abutting and generally sealing relationship with the inner surface **78** of the housing **44**. Notably, the profile of the seed baffle **102** is such that the baffle **102**, when properly positioned relative to housing **44** of the housing assembly **40**, can completely close the opening **96** (**FIG. 11**) at the bottom of the chute **94** through which seed is directed into the seed reservoir of housing **44**.

As shown in **FIGS. 14** and **15**, the seed baffle assembly **100** further includes a linkage assembly **106** that is exteriorly manipulated from outside of housing **44** to effect the disposition of the seed baffle **102** and thereby control the operable size of the opening **96** in the housing **44**. Returning to **FIG. 11**, the rear wall **76** of the housing **44** defines an arcuate slot **108** that extends through the wall **76** and has a radius concentric with the longitudinal axis **84** of the hub **82**. The exterior surface **80** of the rear wall **76** of housing **44** furthermore defines a pivot **110** (**FIG. 15**).

In the illustrated embodiment of the invention, and as shown in **FIGS. 14** and **15**, the linkage assembly **106** of the seed baffle assembly **100** preferably comprises a manually operated elongated lever **112** that extends parallel to the rear wall **76** of housing **44** and is pivotally connected intermediate its ends to a pivot **110** defined on the exterior **80** of housing wall **76**. A free end **113** of lever **112** extends beyond the periphery of the housing **44**. An elongated link section **114** of lever **112** extends parallel to an exterior side **80** of wall **76** and away from the pivot **110** of lever **112**. As will be appreciated, movement of lever **112** will result in pivotal movement of the link section **114**. A second elongated link **116**, arranged parallel to and extending adjacent the outer surface **80** of wall **76**, is articulately joined, at one end, to the free end of link section **114** of lever **112**. At its opposite end, link **116** is connected through the slot **108** to the seed baffle **102** (**FIG. 17**). The connection between and the travel of link **116** of linkage assembly **106** is guided by the arcuate shape of the slot **108**. As will be appreciated, opposite ends of the slot **108** limit the travel of the linkage **106** and thereby the travel of the seed baffle **102** relative to the opening **96** in the rear wall **76** of the

housing **44**.

As shown in **FIGS. 10, 14 and 15**, the exterior surface **80** of wall **76** on housing **44** defines a flange **118** preferably formed integral with the housing **44** and extending generally normal to the major exterior surface **80** of the housing **44**. The flange **118** defines a series of vertically spaced detents or notches **120, 122, 124 and 126**. Each notch or detent **120, 122, 124 and 126** opens to a common side of flange **118** to releasably accommodate the lever **112** therewithin.

In an embodiment of the invention, the lever **112** is sized such that the free end thereof extends radially past the flange **118** for easy and ready manual engagement. In an embodiment of the invention, and to facilitate insertion of the lever **112** into the respective notch **120, 122, 124 or 126**, in the area where the lever **112** passes in proximity to the notches **120, 122, 124 and 126**, the lever **112** is configured with a generally circular cross-sectional configuration. The thickness of each notch or recess **120, 122, 124 and 126** defined on flange **118** closely proximates the diameter of the lever **112**. By such construction, the lever **112** can be manually and readily shifted from one notch to the other while the respective notches furthermore serve to releasably maintain the lever **112** in position selectively chosen by the operator during the functioning of the seed metering mechanism **32**. As will be appreciated, movement of the lever **112** likewise effects displacement of the seed baffle **102** relative to the opening **96** thereby regulating the flow of seeds through the opening and into the seed reservoir **86**.

In the illustrated form of the invention shown in **FIG. 13**, the notches **120 and 126** define the extreme limits of movement of the seed baffle **102** relative to the opening **96** leading to the seed reservoir **86**. Moreover, it should be readily appreciated that less or more notches than that shown can be arranged on the housing **44** without detracting or departing from the spirit and scope of the present invention.

An alternative preferred embodiment of a seed baffle **850** is shown in **FIG. 57**. A body portion **851** and a handle portion **852** are preferably

integrally connected. The seed baffle **850** may preferably be comprised of a single piece of rigid material such as, for example, steel, aluminum, or plastic. Alternatively, a rigid body portion **851** may be combined with a rigid but flexible handle portion **852**. As shown in the embodiments of **FIGS. 58** and **59**, the handle portion **852** is inserted through an arcuate opening **853** formed in the housing **820**, and is received in at least one notch **854** formed in a notch wall **855** which is integrally formed on an outer side **856** of the housing **820**. The housing **820** may preferably be made of, for example, aluminum. As shown in **FIG. 58**, four notches **854** are provided, although the number of notches **854** may vary depending upon the particular application. The notches **854** receive and retain the handle portion **852** into a desired position. A flexible handle portion **852**, for example, will aid in positioning the handle portion **852** in a notch **854** and biasing the handle portion **852** to retain the handle portion **852** within the notch **854** while the seed planter is in operation. As shown in **FIGS. 57** and **59**, the body portion **851** defines an opening **858** that allows the body portion **851** to be mounted for rotation about a hub **859**. As shown in **FIGS. 63a-b**, the housing **820** includes two retaining members **857** which engage the body portion **851** and causes the body portion **851** to remain in contact with an inner surface **857a** of the housing **820** when the seed baffle **850** is installed. One advantage of this arrangement is that no mechanical fasteners are required to mount the body portion **851** to the housing **820**. Moreover, the one piece design eliminates the need for a linkage assembly thereby reducing costs associated with the manufacture and installation of the seed baffle **850**.

In the embodiment shown in **FIG. 59**, the cover **840** may include indicators spaced along the cover **840** to allow the operator to ascertain the size of the seed chamber opening relative to the position of the handle portion **852** of the seed baffle **850**. For example, as shown in **FIG. 59**, reference numerals such as 0, 1, 2, and 3 may be inscribed in the cover **840**, each numeral corresponding to a different notch **854** (see **FIG. 58**). In operation, an operator may position the handle portion **852** into a notch corresponding to numeral 1, for example, to provide a small seed chamber

opening when planting smaller or expensive seeds to prevent an excessive number of seeds from entering the seed chamber which may decrease seed metering efficiency. Alternatively, the operator may position the handle portion **852** into a notch corresponding to numeral 3, for example, to provide a large seed chamber opening when planting large seeds to allow adequate flow from the hopper to maintain an adequate amount of seeds in the seed chamber during operation. The operator may also position the handle portion **852** into a notch corresponding to numeral 0 to completely close the seed chamber opening. Closing the seed chamber opening may be desirable, for example, when draining seeds from the seed hopper.

A schematic illustration of the drive mechanism **200** is provided in **FIGS. 12 and 13**. As shown, the drive mechanism **200** comprises a driven shaft **202** that is rotatably mounted within the bore **83** defined in the housing **44** and coaxial with the longitudinal axis **84** of the seed meter assembly **32**. As shown, the driven shaft **202** has a center section **204** with reduced diameter sections **206** and **208** axially extending from opposite sides of the center section **204** and extending to respective free ends of the shaft **202**. Notably, the differences in diameter between the center section **204** and the reduced diameter section **208** results in the provision of a radial shoulder **210** therebetween. In the illustrated embodiment, the radial shoulder **210** on the shaft **202** abuts with an inward projection defined by the hub **82** on the rear wall **76** of housing **44** thereby limiting axial displacement of the driven shaft **202** to the left as shown in **FIG. 6**.

The reduced diameter section **206** projects outwardly from the rear wall **76** of the housing **44** and has a driven coupler **214** carried at the free end thereof for releasably coupling the driven shaft **202** to a conventional drive coupler mechanism such as that described in U.S. Patent Application entitled "Automatic Coaxial Engagement Drive Coupler" which was filed on April 15, 1998. The driven coupler **214** may be comprised of a plastic resin including, for example, Estaloc™ grade 59600 manufactured by BF Goodrich Company. This particular grade has been found to provide adequate rigidity and is impact resistant. Additives may be added to the Estaloc™ to make the driven

coupler **214** resistant to static charge build-up or to make it electrically
conductive. As shown in **FIGS. 12, 13** and **19**, the driven coupler **214** has a
mounting hub **216** that fits about and is releasably connected to the reduced
diameter section **206** of the driven shaft **202** as with a suitable pin **218** or the
5 like. The driven coupler **214** furthermore includes a driven lug **220** that
axially extends generally parallel to but is disposed in radially spaced relation
relative to the longitudinal axis **84** of the seed metering assembly **32**. As will
be appreciated, movement imparted to the driven lug **220** will likewise be
transferred to the mounting hub **216** and thereby to the driven shaft **202**. As
10 is well known in the art, the driven lug **220** mates with a drive lug provided on
a conventional and well known drive coupler that is disposed on the outside
of the exterior surface **80** of the housing **44** and which conventionally forms
part of the drive coupler mechanism. As will be appreciated by those skilled
in the art, using only a single or one driven lug **220** on the drive mechanism
15 **200** facilitates removal, when necessary, of the hopper **30** and the seed
metering mechanism **32** from the planting unit **14**.

A drive rotor **230** is mounted at the opposite end of driven shaft **202** on
the reduced diameter section **208**. As shown in **FIGS. 20, 21** and **22**, the
drive rotor **230** comprises a mounting hub **232** that fits about and is
20 releasably secured to the reduced diameter section **208** of the driven shaft
202 as with a suitable pin **234** (**FIG. 22**) or the like. Notably, and as shown in
FIGS. 12 and **13**, the mounting hub **232** has a greater diameter than the bore
83 defined in the hub **82** and through which the reduced diameter portion **208**
axially extends. Accordingly, when the drive rotor **230** is fastened to the
25 driven shaft **202**, the driven shaft **202** is prevented from moving to the right as
shown in **FIGS. 12** and **13** by the mounting hub **232** abutting with the hub **82**
in the housing **44** of the seed metering housing assembly **32**.

Returning to **FIGS. 20** through **22**, the drive rotor **230** further includes
first and second driving sections **240** and **250**, respectively, that are arranged
30 in centered relation about the longitudinal axis **84** of the seed metering
mechanism **32**. As shown, the drive rotor **230** includes an enlarged disc-like
member **236** defining a central bore **237** and having generally planar axially

spaced and generally parallel major surfaces **238** and **239**, respectively, radially extending outwardly to the periphery of the drive rotor **230**. Projecting axially outwardly from the major surface **238** of the disc-like member **236** are the first and second driving sections **240** and **250**, respectively.

The first driving section **240** comprises a multi-sided configuration wherein each of the sides of the driving section **240** are equal to each other but define a flat surface area **241** that is axially spaced from and is smaller than the major surface **238** of the disc-like member **236** such that surface **238** acts as a stop for the axial arrangement of subsequent members or pieces placed thereabout as will be described in detail hereinafter. In the illustrated embodiment, driving section **240** has a generally triangular configuration including side surfaces **242**, **244** and **246** that axially project from the major surface **238** of the disc-like member **236** of drive rotor **230**. It will be appreciated, however, that other configurations for the driving section **240** would equally suffice without detracting or departing from the spirit and scope of the present invention. For example, the first driving section **240** could be configured with four equal sides or five equal sides that axially project away from the planar surface **238** of the disc-like member **236**.

The second driving section **250** of the drive rotor **230** likewise comprises a multi-sided configuration that axially extends beyond the first driving section **240**. In the illustrated embodiment, the second drive section **250** comprises a plurality of equally spaced and axially elongated pins **252**. Moreover, the pins **252** are all arranged in a common radial distance from the longitudinal axis **84** of the seed metering mechanism **32**. In the illustrated embodiment, each pin **252** has a generally cylindrical like configuration between opposite ends thereof. It will be appreciated, however, that other pin configurations would equally suffice without detracting or departing from the spirit and scope of the present invention. Moreover, each pin **252** has a chamfered configuration **254** at the distal end thereof for promoting axial placement of the seed metering disc **400** thereover. In the illustrated embodiment, the pins **252** are integrally formed with the disc-like member

236. It will be appreciated, however, that the pins **252** could be formed separate from and then added to the disc-like member **236**.

FIGS. 79-82 illustrate an alternative embodiment of a drive rotor **1130**. The drive rotor **1130** includes a plurality of pins **1132** for engaging a seed disc. The drive rotor **1130** defines a through opening **1134** for mounting the drive rotor **1130**. The through opening **1134** may preferably be keyed in any conventional manner so that drive rotor **1130** can be mounted for rotation in only one direction. Moreover, the pins **1132** may be keyed in any conventional manner to allow proper mounting orientation of a seed disc. As shown in **FIG. 60a**, the seed disc may include a keyed opening **921** for receiving the keyed pin **1132**.

The agitator assembly **300** is arranged in driving relation relative to the drive rotor **230** of the drive assembly **200**. As mentioned, the purpose of the agitator assembly is to inhibit seeds from compacting within the seed reservoir **86** of the housing assembly **32**.

In the illustrated embodiment, and as shown in **FIGS. 23 and 24**, the agitator assembly **300** includes a disc shaped rotor **302** having a central hub **304** and a plurality of flexible and readily replaceable fingers **306** radially extending from the rotor **302**. In the illustrated embodiment, the central hub **304** is axially displaced from the remainder of the rotor **302** and has first and second generally parallel side surfaces **308** and **310**, respectively. Notably, the axial distance separating the first and second surfaces **308**, **310** of the central hub **304** of rotor **302** is generally equal to the axial distance the side surfaces **242**, **244** and **246** project away from the major surface of the disc-shaped member **236** of drive rotor **230** of the drive section **240**.

The central hub **304** of agitator assembly **300** furthermore defines a centrally located through opening **312** that is configured to substantially correspond to the cross-sectional configuration of the first driving section **240** of drive assembly **200**. That is, in the illustrated embodiment, the opening **312** in the rotor **302** of the agitator assembly **300** has a generally triangular configuration that substantially corresponds to the triangular shape of the first driving section **240**. It will be appreciated, however, that changes in the

configuration of the first driving section of drive assembly **200** will be equally reflected in the shape and size of the opening **312** in the rotor **302** of the agitator assembly **300**. As such, when the rotor **302** of agitator assembly **300** is mounted on the first drive section of the drive rotor **230** of drive assembly **200**, a drive connection is established between the drive rotor **230** of drive assembly **200** and the rotor **302** of agitator assembly **300**.

The remaining portion of the disc-shaped rotor **302** radially extending from the central hub **304** has generally parallel first and second side surfaces **318** and **320**, respectively. Toward the periphery of the rotor **302** there are provided a series of equally disposed receptacles **322** for releasably accommodating one end of each finger **306**. Each receptacle **322** has inclined surfaces **324** and **326** projecting angularly away from the side surface **318** of the rotor **302**. Such receptacles **322** act as fins or step-like extrusions. As such, and upon rotation of the rotor **302**, the seed mass in the seed reservoir **86** defined by the housing **44** of the housing assembly **32**, is agitated by the receptacles **322** in a manner preventing the seed mass from compacting itself during operation of the seed metering mechanism **32**. Similarly, the fingers **306** projecting radially outwardly from each receptacle **322** tends to agitate the seed mass in the housing **44** upon rotation of the rotor **302**.

In a preferred form of the invention, the fingers **306** projecting outwardly from the rotor **302** range in size from about 0.080 inches to about 0.095 inches in diameter and are preferably made from a nylon-like material or other suitable flexible material such as that used in grass trimming machines. Preferably, the fingers **306** radially extend outwardly for a distance equal to about 150 mm. Notably, the fingers **306** are disposed in a swept back configuration relative to the direction of rotation of the rotor **302**. As such, should the fingers **306** engage an object along their path of travel, the fingers **306** merely tend to deflect around and out of the way of the obstruction without damaging either the obstruction or the finger **306**. In a most preferred form of the invention, one end of each finger **306** is releasably accommodated within a hole or opening **330** defined by each receptacle **322**

on the rotor **302**. Accordingly, repair or replacement of the fingers **306** is readily and easily effected. It will be appreciated, however, that it is likewise within the spirit and scope of the present invention to form the fingers **306** as permanent cast or integral part of the rotor **302**.

5 **FIGS. 77-78** illustrate an alternative embodiment of an agitator **1100**. In the embodiment shown, a plurality of equally spaced flanges **1101** extend around the periphery of the agitator **1100**. A finger **1102** extends radially outwardly from each flange **1101**. In the embodiment shown, the fingers **1102** are formed as an integral part of the agitator **1100**. The agitator **1100** defines a centrally located through opening **1104** for mounting the agitator
10 **1100**. The through opening **1104** may preferably be keyed in any conventional manner so that the agitator **1100** can be mounted for rotation in only one direction. The advantage of the keying arrangement is that it prevents the agitator **1100** from being mounted improperly. The agitator
15 **1100** may be comprised of aliphatic polyketones including, for example, Carilon® polymers manufactured by the Shell Chemical Company. Additives such as carbon fibers, carbon powder, or stainless steel fibers may be added to the Carilon® polymer to make the agitator **1100** resistant to static charge build-up or to make it electrically conducting. Carilon® has been found to
20 provide a low coefficient of friction and excellent wear for pressure-velocity and abrasive wear applications, good dimensional stability, good lubricity, and good seed handling properties.

As shown in **FIGS. 12 and 13**, the rotor **302** of the agitator assembly **300** furthermore serves to axially urge the seed plate **400** in an axial direction
25 and toward the cover **46** of the housing assembly **32**. In this regard, and as shown in **FIGS. 12, 13 and 26**, the rotor **302** of the agitator assembly **300** includes spring structure **350** for resiliently urging the seed plate **400** toward the cover **46** of the housing assembly **32** to maintain a sealing relationship between the seed disc **400** and the cover **46** throughout operation of the seed
30 metering mechanism **32**.

In the illustrated form of the invention, the spring structure **350** comprises a plurality of leaf springs **352** that are preferably formed integrally

with the rotor **302**. As shown in **FIGS. 25** and **26**, and in the area of the central hub **304**, preferably adjacent and parallel to each side of opening **312**, the rotor **302** includes a plurality of fingers **352**. In the illustrated embodiment, each finger **352** has a cantilevered configuration. That is, each finger **352** is joined at one end to the rotor **302**. The free end of each finger **352**, however, axially projects beyond side surface **308** of the rotor **302** to resiliently engage the seed plate **400**.

During a seed planting operation, the tractor typically moves over the ground at a speed of about 4 to about 8 miles per hour. Seed spacings within the furrows can range between as little as 0.5 inches to as much as 10 inches between adjacent seeds. Accordingly, the rate of discharge from the vacuum seed metering mechanism **32** of the present invention can vary greatly from a very low discharge rate on the order of twenty seeds per second or less such as when the tractor is traveling at only about 4 miles per hour and up to 10 inch seed spacing is required to a very high rate on the order of about 130 seeds per second or greater where the tractor is traveling at a considerably faster speed and a seed spacing as little as 0.5 inches is required. It will be appreciated, therefore, that the seed metering mechanism **32** of the present invention must be capable of dispensing seeds at a rate which can vary considerably. To further complicate matters, the seed metering mechanism **32** of the present invention must be capable of handling different seeds of different sizes and surface characteristics. Ultimately, the important factor to be mastered relates to the ability to dispense seeds accurately.

In this regard, an advantageous feature of the present invention relates to the ability of quickly and easily change seed discs to accommodate the particular seed being planted. Another advantageous feature that is inherent with the design disclosed by the present invention relates to the ability to change seed discs without requiring the use of tools or other fasteners thereby significantly reducing the downtime incurred upon replacement or changing of the seed disc. Suffice it to say, and as shown in **FIGS. 27** and **28**, the seed disc **400** is typically comprised of a metal material. It is also within the spirit and scope of the present invention to fabricate the seed disc **400** from a suitable plastic material. In either embodiment, the

35

seed disc **400** measures about 300 mm. in diameter. The centers of the seed disc openings may be positioned, for example, 17.5 mm from the periphery of the disc (the diameter measured between openings spaced across from each other on the disc being, for example, 265 mm). The 300 mm. size of seed disc **400** is significantly greater than any seed discs currently known in the art and allows greater versatility in planting operations. Each seed disc **400** has a diameter greater than the diameter of the radially outermost sealing face **58** on the cover **46** of the housing assembly **40**.

The seed disc **400** has planar or flat first and second surfaces **402** and **404**, respectively, extending generally parallel to each other. The seed disc **400** furthermore has a plurality of apertures **410** therein arranged in a circumferential row adjacent but inside of a circular outer edge **412**. Each aperture **410** extends through the thickness of the seed disc **400** between the first and second surfaces **402** and **404**, respectively, of the disc **400**. As will be readily appreciated by those skilled in the art, and without departing or detracting from the spirit and scope of the present invention, the seed disc **400** can include additional rows of apertures (not shown) arranged closely adjacent and concentric to the first row of apertures **410**. Notably, the sides or surfaces **402** and **404** of the disc **400** in the area of each opening is substantially planar or flat with the remainder of the disc **400**. That is, the seed disc **400** is void of any recesses or voids arranged in surrounding relation to the openings **410**. The flat configuration of the plate or disc **400** across the entirety thereof and especially in the area of the openings **410** reduces frictional contact of the outer surface of the seeds when they are released from the disc in the discharge area **98** of the seed metering mechanism.

As shown in **FIG. 27**, and toward the center thereof, each seed disc **400** includes a plurality of openings or drive sockets **420** that are equidistantly arranged relative to each other about a common diameter. Notably, the spacing between the openings **420** is equal to the spacing between the driving pins **252** of the second driving section **250** on the drive assembly **200**. Moreover, the shape and size of the apertures **420** in discs

400 correspond to the shape of the pins 252 of the second driving section 250 of drive rotor 230. An important benefit is yielded by such construction. Because the disc 400 is mounted on the driving section 250 of drive rotor 230, the disc 400 and the openings 410 provided therein turn about a fixed axis 84 of rotation. Accordingly, the openings 410 move along a predetermined path of travel as the disc 400 turns or rotates within the housing assembly 40. Moreover, and as will be readily appreciated, different discs 400 are readily interchangeable within the seed metering mechanism 32 to accommodate different seed spacings and/or seeds having particular surface characteristics without the use of tools or fasteners. Notwithstanding the size of the seed disc 400, the openings 410 thereon travel about a predetermined path of travel between the seed chamber 86 and the discharge area 98 of the seed metering mechanism.

FIGS. 60a-b illustrate an alternative embodiment of a seed disc 920. A plurality of openings 922 are spaced along the perimeter of the seed disc 920. As shown in FIG. 60b, the vacuum side 924 of the seed disc 920 includes a plurality of wear depressions 926 formed therein. As shown in FIG. 60b, the wear depressions 926 may, for example, be elongated slots, and are preferably spaced so that the wear depressions 926 extend to where the cover contacts the seed disc. As shown in FIG. 60b, the wear depressions 926 may preferably extend underneath the contact surfaces and into the vacuum chamber to create air flow under the contact surfaces to allow cooling of the contact surfaces. The wear depressions 926 also channel debris away from the contact surfaces. In the embodiment shown, the wear depressions 926 may preferably be angled with respect to the radius of the seed disc to aid in debris removal. For example, the wear depressions 926 may be angled at approximately 45 degrees, although other angles may be adequate. The size, shape, and orientation of the wear depressions 926 may vary depending on the particular application, and various configurations, including a curved depression, are contemplated. The seed disc preferably includes a center opening 927 to allow the shaft to extend through the opening 927. This allows closer tolerances to be held

37

and better alignment between the singulator spools and the seed disc openings.

The size, shape and configuration of openings **922** may vary depending on the particular seed to be planted. Moreover, the openings **922** may be chamfered on the vacuum side **924** of the seed disc **920** to aid in the removal of seed debris from the openings **922**. The spacing of the openings **922** shown in **FIGS. 60a-b** may be suitable for crops such as, for example, corn. **FIGS. 60c-d** illustrate an alternative embodiment of a seed disc **928**, which shows two rows of openings **929** which are off-set from one another for planting high density crops such as, for example, soybeans. The diameter of the discs may be, for example, 300 mm, and the diameter between the seed openings positioned on opposite sides of the disc, may be, for example, 265 mm.

FIGS. 61a-b illustrates an alternate embodiment of a seed disc **900** for a multiple seed drop application. As shown in **FIGS. 61a-b**, the seed disc **900** includes a plurality of spaced-apart clusters of openings **902** which are oriented adjacent the perimeter of the seed disc **900**. This arrangement allows the seeds to drop at substantially the same time as the disc rotates the cluster out of communication with the vacuum chamber. Each of the clusters **902** may be comprised of two or more openings **904** depending on the particular application. In the embodiment shown, four openings **904** are provided in each cluster **902**. As shown in **FIGS. 61b** and **62b**, a recessed area **906** is formed on the vacuum side **907** of the seed disc **900** and interconnects the openings **904**. In the embodiment shown, the recessed area **906** may also include a ramp portion **908**. In operation, a vacuum force is simultaneously applied to all four seeds due to the interconnection of the openings **904** by the recessed area **906**, which retains the seeds on the seed disc **900**. When the recessed area **906** exits the vacuum area, the vacuum force applied to all four seeds is cut-off simultaneously allowing all four seeds to fall from the seed disc **900** with negligible time delay between the seeds. This allows all four seeds to be dropped in a tight group which is desirable in certain applications including, for example, "hill-drop" cotton planting. The

recessed area **906** may be any shape, size as configuration sufficient to link the openings **904** together so that when the recessed area **906** exits the vacuum area all of the seeds of the cluster **902** drop simultaneously.

Alternatively, the openings **904** may be linked by any other passageway which communicates with each of the openings **904** to allow all of the seeds of the cluster **902** to drop simultaneously when the passageway exits the vacuum chamber.

The seed disc **900** may be comprised of aliphatic polyketones including, for example, Carilon® polymers manufactured by the Shell Chemical Company. Additives such as carbon fibers, carbon powder or stainless steel fibers may be added to the Carilon® polymer to make the seed disc **900** resistant to static charge build-up or to make it electrically conductive. Carilon® has been found to provide excellent wear for pressure-velocity and abrasive applications, good dimensional stability, good lubricity, and good seed handling properties.

As stressed throughout, an important aspect of seed metering mechanism **32** of the present invention relates to the ability to dispense the seeds to the ground with accuracy. This means that one seed and no more than one seed is planted at any desired location along the length of the furrow. As well known in the industry, dispensing or discharging more than one seed into the furrow at any single location, sometimes referred to as "doubling", is undesirable at the very least and is unacceptable for the majority of planting operations. The typical unavailability of suitable nutrients in the soil will simply not sustain or support the presence of two seeds at any single location.

For these and other reasons, and as shown in **FIG. 29**, the seed metering mechanism **32** of the present invention furthermore includes a singulator assembly **500**. During operation of the seed metering mechanism **32** of the present invention, a suction is created in chamber **50** of housing **46**. As such, and as the apertures **410** on the seed disc **400** move through the seed mass in the seed reservoir **86** of housing **44**, one or more seeds releasably attach themselves to the openings **410** in the seed disc under the

influence of pressure differentials. As the seed disc **400** is drivingly rotated, the one or more seeds operably associated with each opening or aperture **410** moves with the seed disc toward the discharge area of the seed metering mechanism **32**. Intermediate the location where at the seeds operably attach themselves to the seed disc **400** and the seed discharge area of the seed dispensing mechanism from which the seeds gravitationally fall to the ground, the singulator assembly **500** of the present invention is provided to insure that one and only one seed is present in each opening or aperture **410** as the particular seed pocket or opening approaches the discharge area of the seed dispensing mechanism **32**. The seed singulator mechanism is indicated generally by reference numeral **500** in **FIG. 29**. In the illustrated form of the invention, the singulator assembly **500** is shown attached to the backwall **78** of housing **44** of the housing assembly **40** as through a plurality of suitable fasteners **502** and **504** and is less sensitive to revolving speed of the seed disc **400** than are known seed singulator devices.

Turning to **FIG. 30**, the singulator assembly **500** is shown in exploded perspective view. As shown in **FIG. 30**, the singulator assembly comprises a base **510**, a pair of manually movable brackets **530** and **550**, a manually operated adjustment mechanism **570**, and a cover **590**. Notably, one of the unique features of the present invention concerns the ability of the component parts of the singulator assembly **500** to be assembled and adjusted relative to each other without the use of screws or other fasteners. Accordingly, no tools are required for assembly or adjustment of the singulator assembly of the present invention thereby reducing downtime normally incurred during the planting operation when adjustment of the seed singulator is required or desired. Another salient aspect of the singular assembly **500** relates to the provision of at least three singulator spools **700** that are mounted in specifically spaced relation relative to the path of travel of the apertures **410** of the seed disc **400**.

Turning now to **FIGS. 31** through **33**, the base **510** of the singulator assembly **500** includes a generally rectangular back wall **512** having a back side **513** and a front side **514**. Preferably, wall **512** of base **510** further

includes a closed rim **515** extending about the peripheral edge of the back wall **512** and axially away from the front side **514** to define an enclosure or open cavity **516**. A pair of vertical disposed and horizontally spaced rails **518** and **520**, respectively, are provided within the enclosure **516**. As shown in

5 **FIG. 31**, the rails **518** and **520** are preferably integrally formed with the base **510**. It will be appreciated, however, that rails **518**, **520**, which are independently formed relative to the base **510**, would equally suffice.

Apertured flanges **522** and **524** extend outwardly from the base **510** so as to allow releasable affixation of the base **510** to the housing **44** of the housing

10 assembly as with suitable fasteners. Moreover, base **510** furthermore defines a central throughbore or opening **526** with radially elongated slots **527** and **528** that pass entirely through the base **510**. The slots **527** and **528** are arranged in diametrically opposed relation relative to each other and in generally concentric relationship relative to the bore or opening **526**.

15 An alternative embodiment of a singulator assembly **1500** is shown in **FIGS. 64** through **76**. In particular, **FIG. 64** illustrates the seed metering mechanism of the present invention including the singulator assembly **1500**. The singulator assembly **1500** is shown assembled in **FIG. 65**, while **FIG. 66** illustrates an exploded perspective view of the singulator assembly **1500**.

20 The various components of the singulator assembly are more fully illustrated in **FIGS. 67** through **76** and explained in more detail below.

FIGS. 67 and **68** illustrate an alternative embodiment of the base **1510** of the singulator assembly **1500** shown in **FIG. 67**. In the embodiment shown in **FIGS. 67** and **68**, the base **1510** includes a plurality of flanges **1522**, **1523** and **1524** which extend outward from the base **1510**. The flanges **1522**, **1523** and **1524** are preferably integrally formed with the base **1510**. It will be

25 appreciated, however, that flanges **1522**, **1523** and **1524** which are independently formed relative to the base **1510** would equally suffice. As shown in **FIG. 68**, each flange **1522**, **1523**, and **1524** includes a protrusion

30 **1720** which projects from the flange. As shown in **FIG. 68**, each flange **1522**, **1523** and **1524** further includes a locator pin **1721**. In the embodiment shown in **FIG. 69**, a backwall **1078** of a housing **1079** defines a plurality of slots

1723 which are complementary in shape and size to the protrusions 1720 on each of the flanges 1522, 1523 and 1524. As shown in FIG. 69, the backwall 1078 of the housing 1079 further defines a plurality of apertures 1724 which are complementary in shape and size to the locating pins 1721. Thus, to
5 releasably affix the base 1510 to the backwall 1078 of the housing 1079, the base 1510 is preferably snap-fit to the backwall 1078. In particular, the protrusions 1720 are inserted into the complementary slots 1723 in the backwall 1078, while the locating pins 1721 are inserted into the complementary apertures 1724 in the backwall 1078.

10 One embodiment of the bracket 530 is shown in FIGS. 34 through 36. As shown, bracket 530 includes a slidable member 532 that is preferably formed from hard plastic or nylon and is configured to slidably fit for vertical movement within the recess or opening 516 of base 510. Bracket member 532 includes a top surface 534 and a bottom surface 536. A pair of vertically
15 disposed and horizontally spaced channels 538 and 540, respectively, are provided and extend along the bottom surface 536 of the bracket member 532. Notably, the size and spacing of the channels 538 and 540 are complementary to the size and spacing of the rails 518 and 520 on the base 510. Bracket member 532 further defines a plurality of horizontally spaced and internally threaded recesses 542, 544 and 546. The threaded recesses
20 542, 544 and 546 defined by bracket 532 are located in circumferentially spaced relation relative to each other on a common line of centers or a radius which is generally equal to the radius about which the holes or apertures 410 in the seed disc 400 are disposed. Bracket 532 further defines an elongated
25 generally horizontal slot or opening 548 that passes between and opens to both the top and bottom surfaces 534 and 536, respectively, of the bracket member 532.

FIG. 70 illustrates an alternative embodiment of a bracket 1530. The bracket 1530 includes a plurality of horizontally spaced recesses 1542, 1544
30 and 1546. As shown in FIG. 66, a plurality of metal inserts 1657 which are threaded are provided to be inserted into and retained in the recesses 1542, 1544, 1546 of the bracket 1530. Preferably, the metal inserts 1657 are nuts.

One embodiment of the bracket **550** is shown in **FIGS. 37** through **39**. As shown, bracket **550** includes a slidable member **552** that is preferably formed from hard plastic or nylon and is configured to slidably fit for vertical movement within the recess or opening **516** of base **510** in vertically disposed relation to bracket **530**. Bracket member **552** includes a top surface **554** and a bottom surface **556**. A pair of vertically disposed and horizontally spaced channels **558** and **560**, respectively, are provided and extend along the bottom surface **556** of the bracket member **552**. Notably, the size and spacing of the channels **558** and **560** are complementary to the size and spacing of the rails **518** and **520** on the base **510**. Bracket member **552** further defines a plurality of horizontally spaced and internally threaded recesses **562**, **564** and **566**. The threaded recesses **562**, **564** and **566** defined by bracket **552** are likewise located on a common radius which is generally equal to the radius about which the holes or apertures **410** in the seed disc **400** are disposed. Bracket **552** further defines an elongated generally horizontal slot or opening **568** that passes between and opens to both the, top and bottom surfaces **554** and **556**, respectively, of bracket member **552**.

FIG. 71 illustrates an alternative embodiment of a bracket **1550**. The bracket **1550** includes a plurality of horizontally spaced recesses **1562**, **1564** and **1566**. As shown in **FIG. 66**, a plurality of metal inserts **1657** which are threaded are provided to be inserted into and retained in the recess **1564** of the bracket **1550**. Preferably, the metal insert **1657** is a nut.

One embodiment of the manually operated adjustment mechanism **570** for the singulator assembly is shown in **FIGS. 40** through **42**. As shown, the adjustment mechanism **570** comprises an elongated lever **572**. The lower end of lever **572** is provided with a mounting pin **574** and a pair of actuating pins **576** and **578** disposed in equally spaced relation and on opposite sides of the mounting pin **574**. Notably, the mounting pin **574** is preferably formed integral with the lever **572** which is formed from plastic or nylon.

With the brackets **530** and **550** arranged in the enclosure **516** defined by base **510**, the lever **572** is arranged on the backside **513** of the base **510**.

and the mounting pin **574** is inserted endwise through the opening **526** in the base **510**. Notably, the diameter of the mounting pin **574** is substantially equal to the diameter of the hole or opening **526** in the base **510** such that the lever **572** is permitted to pivotally move and rock about an axis **575** defined by the mounting pin **574**. Similarly, the actuating pins **576** and **578** on the lever **572** project endwise through the arcuate slots **527** and **528**, respectively, of the base **510**. As such, the actuating pin **576** on lever **572** projects into the slot or opening **548** defined on bracket **530** while actuating pin **578** projects into the slot or opening **568** defined on bracket **550**. As will be appreciated by those skilled in the art, this arrangement allows the brackets to vertically move toward and away from each other along the rails **518** and **520** defined in the enclosure **516** of base **510** in response to manual pivotal or rocking movement of the lever **572** about the axis **575**. To facilitate movement of the lever **572**, the upper end of lever **570** is provided with a handle **580** that projects generally normal to the handle or lever **72** to readily allow manual manipulation of the handle or lever **570**.

One embodiment of the cover **590** for the singulator assembly **500** is schematically illustrated in **FIGS. 43** and **44**. The cover **590** preferably includes a generally rectangular front wall **592** having a closed rim **594** extending about the peripheral edge thereof. Notably, the configuration of the front wall **592** and the rim **594** closely proximates if not corresponds to the configuration of the back wall **512** and closed rim **514** on base **510**. Cover **590** furthermore includes a central throughbore or opening **596** that is adapted to resiliently receive the free end of the mounting pin **574** of lever **572**. Preferably, the free end of the mounting pin **574** is configured to resiliently fit through the opening **596** in the front wall **592** of cover **590** in a manner securing the front wall **592** of cover **590** to the base **510** without use of further fasteners and yet allowing access to the interior of the singulator assembly when required.

Cover **590** further defines a plurality of vertically aligned and horizontally spaced pairs of openings **600**, **602** and **604**. Each vertically aligned pair of openings **600**, **602** and **604** comprises two vertically

elongated slots **606** and **608**. As will be appreciated, the horizontal spacing between the pairs of openings **600**, **602** and **604** is equal to the horizontal spacings between the threaded recesses **542**, **544** and **546** of bracket **532** and the recesses **562**, **564** and **566** of bracket **552**. As will be appreciated, the elongated configuration of the openings **600**, **602** and **604** allows for vertical displacement of the brackets **530** and **550** within the recess **516** of the base **510**.

FIG. 72 illustrates an alternative embodiment of the cover **1590**. The cover **1500** defines a plurality of openings **1600**, **1602** and **1604**. As will be appreciated, the spacing between the openings **1600**, **1602** and **1604** corresponds to the spacing between recesses **1542**, **1546** of the bracket **1530** shown in **FIG. 70** and the recess **1564** of the bracket **1550** shown in **FIG. 71**. The elongated configuration of the openings **1600**, **1602** and **1604** allows for vertical displacement of the brackets **1530** and **1550** within the cavity of the base.

Moreover, in the alternative embodiment shown in **FIG. 72**, the cover **1590** includes a plurality of guides **597**. The guides **597** are utilized to retain a meter screen **780**, which is shown in **FIG. 64**. As shown in **FIG. 72**, each guide **597** includes a pair of projections **598**, **599** which extend outward from the front wall **1592** of the cover **1590**. The projections are sized and shaped to hold a meter screen **780**. The meter screen **780** is provided to insure that seeds do not exit out of the housing of the seed metering mechanism. In particular, the agitator assembly of the present invention, as it agitates seeds in the seed reservoir, may cause seeds to fly up toward the top of the housing. If this occurs, the meter screen **780** shown in **FIG. 64** prevents seeds from exiting the top of the housing by blocking seeds from exiting the top of the housing. Preferably, the meter screen **780** is formed of a plastic material. In addition, the projections **598**, **599** shown in **FIG. 72**, are formed of a plastic material. Furthermore, each projection **598** is generally rectangular in shape and is positioned in a close relationship to its paired projection **599** such that the distance between the projections **598**, **599** is proximate enough to retain the meter screen **780** within the projections **598**,

599. The projections **598**, **599** are preferably independently formed relative to the cover **590**. It will be appreciated, however, that projections **598**, **599** which are integrally formed with the cover **590** would equally suffice.

As shown in **FIG. 72**, the cover includes two guides **597**, with each guide **597** having its own pair of projections **598**, **599**. Thus, in this embodiment, the meter screen **780** is slid or pushed through one guide **597** (with its projection **598**, **599**) into the second guide **597** (with its projections **598**, **599**). As shown in **FIG. 72**, two guides **597** are preferably used as part of the singulator assembly. It will be appreciated, however, that additional guides **597** may be formed on the cover **1590** to be utilized to retain the meter screen **780**.

Cover **590** furthermore defines a generally vertical upstruck and arcuate bracket **620** that is generally coplanar with the top surface **622** of the cover **590**. Notably, the bracket **620** has a relatively thin construction and thus a void or space **624** is provided on the rear side of the bracket **620**. It is within this space or void **624** wherein the upper end of the lever **572** moves. Moreover, the bracket **620** is configured such that the handle **590** of lever **572** can extend thereover. Additionally, the top surface of the bracket **620** has indicia **630** thereon for readily providing a visual indication of the position of the lever **572**.

The singulator assembly **500** further comprises a series of mounting studs **650** on which the singulator spools **700** are mounted. An exemplary form of stud **650** for mounting a single singulator spool **700** to the singulator assembly **500** is shown in **FIGS. 45** and **46**. As shown, each stud **650** comprises an elongated member **654** having a shank portion **655** with a shouldered and externally threaded end **656** and an enlarged head portion **658** at an opposite end thereof. Preferably, each stud member **654** is formed of metal. In the illustrated embodiment, each stud **650** is provided with a series of axially extending external splines **660** axially extending from the head portion **658** of each stud for about one-half the length thereof. Each stud **650** is provided with 4, 6, 8, 12 or more splines **660** as desired. Notably, the outside diameter of the stud member **654** is sized such that it is permitted

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46

to endwise pass through the vertically elongated slots **606** and **608** comprising each pair of openings **600**, **602** and **604** in the cover **590** of the singulator assembly **500**. Moreover, the external threading at end **656** of each stud member **654** corresponds to the internal threading or a metal insert (nut) within the recesses **542**, **544** and **546** of bracket **530** (FIGS. 34 through 36) and within the recesses **562**, **564** and **566** of bracket **550** (FIGS. 37 through 39). Furthermore, it should be noted that the axial length of each spool member **702** is less than the axial distance separating the enlarged head portion **658** and the external threading **656** of each spool mounting stud **650**.

FIGS. 73 through 76 illustrate an alternative embodiment of the mounting studs **1650** and the singulator spools **1700** of the present invention. As shown in FIG. 73, each stud **1650** is comprised of a shank portion **1658** with an externally threaded end **1659**. Preferably, each stud **1650** is formed of metal. More preferably, each stud **1650** is formed of brass. Notably, the outside diameter of the stud **1650** is sized such that it is permitted to endwise pass through the openings **1600**, **1602** and **1604** in the cover **1590** shown in FIG. 72. Moreover, the external threading at end **1659** of each stud **1650** corresponds to the metal inserts **1657** (see FIG. 66) which are inserted into the recesses **1542**, **1546** of the bracket **1530** shown in FIG. 70 and within the recess **1564** of the bracket **1550** shown in FIG. 71. As stated above, the metal inserts **1657** are preferably nuts which are inserted into the recesses **1542**, **1546** of the bracket **1530** and recess **1564** of the bracket **1550** and are sized and shaped to be retained therein. Thus, in order to retain the studs **1650** to the brackets **1530**, **1500**, the threaded end **1659** of each stud **1650** is threadably connected to the metal inserts **1657**. The studs **1650** are thus removably threaded to the brackets **1530**, **1550**. Therefore, when the studs wear and need to be replaced, the worn studs may be removed and replaced by new studs.

An exemplary form of singulator spool **700** is schematically illustrated in FIGS. 47 through 50. As shown in FIG. 47, each singulator spool **700** comprises an elongated preferably metal tubular member **702** defining a

longitudinal axis **704** which, when mounted to the seed metering mechanism, extends generally normal or perpendicular to the sides of the seed disc **400**. In the illustrated embodiment, and at that end **706** of each spool disposed closely adjacent the seed disc **400** during operation of the seed metering mechanism, each spool member **702** preferably has a seed engaging portion projecting radially outwardly from the remainder of the spool. As shown, each spool member **702** preferably has a flared or frusto-conical seed engaging or surface configuration extending away from a planar bottom surface **707** defined by the spool member **702**. As shown in **FIGS. 47, 49 and 50**, the flared profile at the free end **706** of each spool **700** increases in diameter toward end **706**. Moreover, and as shown in **FIGS. 47, 49 and 50**, the bottom planar edge **707** of the spool **700** and the flared end **706** intersect with each other to define a relative sharp edge **709** extending about the periphery of the spool **700**.

The singulator spool members **702** may be comprised of aliphatic polyketones including, for example, Carilon® polymers manufactured by the Shell Chemical Company.

As shown in **FIG. 48**, the peripheral edge **710** of the free end **706** of spool member **702** has a changing or eccentric profile relative to the longitudinal axis **704** of the spool member **702**. That is, the seed engaging portion of each arcuate segment of the edge **710** of the enlarged free end of the spool member **702** is disposed at different radial distance from the longitudinal axis **704** of the spool member **702**. The changing or eccentric profile allows or permits a changing circumferential surface area of the seed deflector portion of each spool **700** to be selectively positioned relative to the predetermined path of travel of the openings thereby changing the spacing of the seed deflector relative to the fixed path of travel of the openings **410** in the seed disc **400** and relative to each other. In this regard, and as shown in **FIG. 47**, the spool member **702** has a locating mark **703** thereon for providing a visual indication of the setting of the seed deflector **706** relative to the fixed path of travel of the seeds carried by the disc **400**. In the illustrated embodiment, the locator or indicating mark **703** is provided adjacent or on the

seed engaging surface portion of the seed deflector. It will be appreciated, however, that the locating or indicating mark can be provided elsewhere on the spool **700** without detracting or departing from the spirit and scope of the present invention.

5 As shown in **FIGS. 49** and **50**, each spool member **702** further defines an opening **712** extending axially through the spool member **704**. As will be appreciated, rather than providing the peripheral edge **710** of the seed contacting surface eccentric relative to the axis **704** of the spool, it is also within the spirit and scope of the present invention to provide the opening

10 **712** in eccentric relationship relative to the spool member. At the flared end **706**, the opening **712** in each spool member **704** has an enlarged counterbore portion **714** that is sized to accommodate the enlarged head portion **658** of the mounting stud **650** (**FIGS. 45** and **46**). The counterbore portion **714** of opening **712** is recessed or has a depth that allows the spool

15 to be endwise moved without exposing the head portion **658** of the spool mounting **650** therebeyond. Because the enlarged counterbore portion **714** and the opening **712** are of different diameters, a radial wall or annular shoulder **713** is defined therebetween. Upon assembly, the enlarged head portion **658** engages with the annular shoulder **713** thereby limiting

20 movement of the spool **700** relative to side of the seed disc **400**. As mentioned, the overall length of the spool member **702** is less than the length of the mounting stud **650** thereby allowing axial or endwise displacement of the spool member **702** along the length of the stud **650**. In this regard, a lengthwise portion of the opening **710** is provided with a series of internal

25 splines **720** that are engagable with the external splines **660** on each mounting stud **650** for holding the seed engaging portion of the respective spool **700** in releasably fixed relation relative to the axis of rotation **704**.

As mentioned above, the end **706** of each spool **700** has a flared or frusto-conical configuration. The slanted or angular configuration at the free

30 end **706** of the spool **700** changes as a function of the angular orientation of the slanted surface relative to the longitudinal axis **704** of the spool **700**. That is, the angular orientation of the flared end **706** of spool **700**, in the area

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49

shown by lines 49-49 in **FIG. 48**, is equal to about a 45 degree angle relative to the planar bottom edge of the spool **700**. In contrast, the angular orientation of the flared end **706** of spool **700**, in the area shown by lines 50-50 in **FIG. 48**, may equal about 45 degrees to 50 degrees relative to the planar bottom edge **707** of the spool **700**. As will be appreciated, the inclined surface configurations extending about the seed engaging portion of each spool defines an included angle ranging between about 35 degrees and about 70 degrees between the inclined surface configuration and the adjacent face or side of the seed disc **400**. Accordingly, different effects or removal forces can be imparted to the seeds carried on the seed plate as a function of which angular orientation of the spool **700** is disposed relative to the seed pocket or opening **410** in the seed plate **400**.

As will be appreciated, the changing profile of the free edge **710** allows the disposition of the spool **700** to be manually changed relative to the path of movement of the openings **410** on the seed disc **400** moving therepast. The interaction of the external spline like configurations **660** on the stud **650** and the internal spline like configurations **720** on the spool **700** prevent the spool **700** from turning or rotating relative their respective stud **650**. Also, however, it is important to note that the interaction between the splines **660** and **720** allows the angular orientation of the spool **700** to be angularly adjusted as required to effect the necessary action relative to the seeds carried by the seed plate **400** toward the discharge area of the seed metering mechanism **32** of the present invention. It will be readily appreciated, of course, that the opening **710** in the spool **700** can be eccentric relative to the longitudinal axis **704** of the spool member **702** thereby effecting different adjustments of the spool **700** relative to the circular path of travel of the openings **410** in the seed disc **400**.

An alternative embodiment of the singulator spool **1700** of the present invention is illustrated in **FIGS. 74** through **76**. As shown, in this embodiment, each spool **1700** is comprised of an elongated tubular member **1702** having a longitudinal axis **1704** which, when mounted to the seed metering mechanism, extends generally normal or perpendicular to the sides of the

seed disc. Preferably, the tubular member **1702** is formed of metal. More preferably, the tubular member is formed of a plastic material or nylon. Even more preferably, the tubular member is formed of Carilon® polymers, which is manufactured by the Shell Chemical Company. Additives such as carbon
5 fibers, carbon powder, or stainless steel fibers may be added to the Carilon® polymer to make the spool members **702** resistant to static charge build-up or to make it electrically conducting. Carilon® has been found to provide excellent wear for pressure-velocity and abrasive applications, good dimensional stability, good lubricity, and good seed handling properties. In
10 addition, Carilon® has similar properties to nylon, but, unlike nylon, Carilon® does not swell when subjected to moisture and thus Carilon® has more dimensional stability than nylon. As shown in **FIGS. 65** and **66**, each spool **1700** is mounted on a respective mounting stud **1650** (shown in **FIG. 73**) with a retaining ring **1703** retaining the spool **1700** onto the stud **1650**. The
15 spools **1700** are thus removably attached to the studs **1650**. Therefore, when the spools **1700** wear and need to be replaced, the worn spools may be removed and replaced by new spools.

In the embodiment shown in **FIGS. 65, 66, and 74 through 76**, at the end of the spool **1700** that is disposed closely adjacent to the seed disc during operation of the seed metering mechanism is the bottom edge **1707**.
20 At the bottom edge **1707**, each spool member **1702** preferably has a seed engaging portion **1706** which projects radially outward from the remainder of the spool **1700**. As shown, each spool member **1702** has a flared or frusto-conical seed engaging portion **1706** which extends away from a planar
25 bottom edge **1707** defined by the spool member **1702**. In addition, the flared portion **1706** of each spool **1700** increases in diameter toward the bottom edge **1707**.

Therefore, in the embodiment shown in **FIGS. 65, 66, and 74 through 76**, the flared portion **1706** of the spool **1700** serves to perpendicularly lift and
30 remove unwanted multiples of seeds from the seed disc **400** such that gravity can act thereon and return the multiple seeds to the seed reservoir of the seed metering mechanism **32**. Moreover, the flared portion **1706** on each

spool member **1700** also disrupts and gently separates a multiplicity of seeds that are held together on one seed hole in the seed disc thereby allowing the multiple seeds to fall under the influence of gravity and return to the seed reservoir of the seed metering mechanism **32**.

5 When assembled to the seed metering mechanism, each spool **1700** is arranged such that the flared end **1706** extends into the path of travel of the seed apertures. In a preferred form of the invention, each spool **1700** is adjusted such that the flared end **1706** covers approximately one-half of the diameter, or less, of each aperture **410** of the seed disc **400**. In another
10 preferred form of the invention, each spool **1700** is adjusted such that the flared end **1706** covers approximately one-third of the diameter, or less, of each aperture **410** of the seed disc **400**.

 In the embodiment of a spool **1700** shown in **FIGS. 74** through **76**, the inner diameter of the spool **1700** is cylindrical or round. In this manner, the
15 spools **1700** may spin on the mounting studs **1650** shown in **FIG. 73**. Because the inner diameter of the spools **1700** are cylindrical, the wear between the spools **1700** and the seed disc will be spread over a larger surface area. In addition, in this embodiment, because the inner diameter of the spools **1700** are cylindrical, the spools **1700** do not have a changing
20 profile relative to the path of travel of the openings in the seed discs. Therefore, the singulator assembly **1500** is not adjusted by turning or rotating the singulator spools **1700** relative to its mounting stud **1650**. Instead, the only adjustment of the singulator assembly **1500** in this embodiment is through the use of the handle to move the brackets **1530** and **1550** that carry
25 the singulator spools **1700** with respect to the base **1510**. This allows the operator to adjust for seeds having different shapes and sizes to vary the spool configurations.

 Returning to **FIG. 30**, each spool **700** is mounted on a respective mounting stud **650** as shown. Notably, however, there is further provided a
30 compression spring **760** or other form of resilient means for resiliently urging the spool axially outward and away from the cover **590** toward the seed disc **400**. As such, the planar bottom surface of the spool **700** is resiliently urged

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toward an adjacent relationship with the seed plate **400** and the edge of the spool serves to engage and orient the seeds traveling toward the discharge area of the seed metering mechanism **32**. The spring **760** furthermore allows the spool to be axially displaced against the action of the spring **760** until the cooperative instrumentalities, which in the illustrated embodiment includes the splines **660** on mounting member **650** and the splines **720** of the spool **700**, are released from each other thereby allowing rotation of the spool **700** about the axis **714** thereby adjusting the seed engaging surface relative to the predetermined path of the openings **410** on the seed disc **400**. As mentioned, the recessed bore **714** is sized to allow for axial displacement of the spool **700** relative to the mounting member **650** without exposing the head portion **658** thereof. After the seed engaging portion of the spool is properly positioned relative to the path of travel of the seed openings **410** in the disc **400**, the spool **700** is automatically returned to an operable position wherein the seed engaging portion is disposed adjacent the side of the disc **400** under the influence of the compression spring **760**. Thereafter, the cooperating instrumentalities on the mounting member **650** and spool releasably hold the seed engaging portion of the spool in fixed relation relative to the axis **714**.

With the present invention, a single singulator spool or up to six singulator spools can be used as part of the singulator assembly **500**. As shown in **FIG. 29**, in a preferred form of the invention, normally two singulator spools **700** will be arranged to one side of the arcuate path of travel of the openings in the seed disc **400** while at least one singulator spool **700** will be arranged on the opposite side of the arcuate path of travel of the openings **410** in the seed disc **400**. As will be appreciated from an understanding of the present invention, the singulator assembly **500** offers several degrees of adjustment for orientating the seeds within the pockets or openings **410** of the disc **400** as well as for disengaging surplus seeds from the plate **400**. First, the singulator spool **700** may be individually adjusted by turning or rotating the singulator spool **700** relative to its respective mounting stud **650**. Thus, different profiles on the singulator spool **700** can be properly orientated

relative to the path of travel of the openings between adjacent spools **700**.

Alternatively, the singulator assembly **500** can be adjusted through use of the handle **570**, to move the brackets **530** and **550** that carry the singulator spools **700**. As will be appreciated, movement of the brackets **530** and **550** endwise within the cavity **516** defined by base **510** will move the singulator spools **700** carried by the brackets **530** and **550** relative to the arcuate path of travel of the openings **410** on the seed disc **400** thereby further effecting adjustment of the singulator apparatus **500**. To properly adjust the brackets **530** and **550** and the spools **700** carried thereon relative to the fixed path of travel of the openings **410** in the disc **400**, the indicia **630** provided on the cover **590** of the singulator apparatus **500** visually guides the operator to adjust the spools **700**.

Still another salient feature of the present invention relates to improving the release of the seeds from the seed disc **400** at the discharge area **98** of the seed metering mechanism **32**. Testing has revealed that imparting vibrations to the housing assembly **40** of the seed metering mechanism **32** facilitates the release of seeds from the seed plate **400** in the discharge area of the mechanism **32**. In this regard, and as shown in **FIG. 11**, there is preferably provided a mechanism **800** for imparting vibrations to the housing assembly **40**. The vibration imparting mechanism **800** can take a myriad of shapes and sizes. Mechanism **800** can be driven in any suitable manner. Preferably, a mechanism that produces vibrations in the range of about 115 hz. to about 135 hz. appears to work well. In the illustrated form of the invention, an electrically operated vibration type mechanism including a housing **802** is securely fastened in and about the seed discharge area **98** of the seed metering mechanism and appears to operate satisfactorily. As will be appreciated, the vibration mechanism **800** can be mounted inside or outside of the housing **40** without departing or detracting from the spirit and scope of the present invention. Moreover, the vibrating mechanism **800** can be secured to the cover **46** to impart vibrations to the housing assembly **40**.

From the foregoing, it will be observed that numerous modifications and variations can be effected without departing from the true spirit and

scope of the novel concept of the present invention. It will be appreciated that the present disclosure is intended as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated. The disclosure is intended to cover by the appended claims all
5 such modifications as fall within the scope of the claims

While the embodiments of the invention disclosed herein are presently considered to be preferred, various changes and modifications can be made without departing from the spirit and scope of the invention. The scope of the invention is indicated in the appended claims, and all changes that come
10 within the meaning and range of equivalents are intended to be embraced therein.

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